Indian J. Phys. 64A (5), 381-386 (1990)

Characterization of X-ray film base and overhead projector transparency as nuclear track detector

Swarnali Ghosh, Atul Saxena+ and K K Dwivedi
Department of Chemistry, North-Eastern Hill University, Shillong-793 003, India

Abstract : In the search for newer detector materials at low cost and easy procurability attempts have been made to characterize X-ray film base and overhead projector transparency. ^{252}Cf source was used to irradiate the materials and the optimum etching conditions for both the detectors were determined. The detectors were characterised in terms of the different parameters of etched tracks of ^{208}Pb ions and fission fragments. The effect of UV-radiation prior to track registration in X-ray film base was also studied.

Keywords : ^{252}Cf source, X-ray film base, overhead projector transparency, true track length, nuclear track detectors.

PACS Nos : 29.40.-n, 29.70.-e

1. Introduction

Low cost, uniformity, high sensitivity and easy availability of a dielectric material are some of the important factors which decide its ultimate utility as a nuclear track detector. Two types of plastics, viz. X-ray film base and overhead projector transparency, can be easily procured and employed as particle track detectors. In the present work we have assessed the applicability of these two plastics as track detectors for ^{252}Cf fission fragments and 17.1 MeV/u ^{208}Pb ions. The optimum conditions for track development have been determined in these detectors and the influence of UV-radiation on the X-ray film base have been studied. These new detectors are also characterized in terms of maximum etchable track lengths of ^{252}Cf fission fragments and ^{208}Pb ions. The experimental track lenghts are compared with theoretical values and the results are discussed.

2. Experimental

2.1. *Preparation of detector foils*

X-ray film base was prepared for use by first dipping ordinary X-ray films in hot concentrated NaOH solution. The gelatine layer was removed and a pale blue

+Present address : Department of Physics, Pachhunga University College, NEHU, Aizawl (Mizoram), India.

X-ray film base was obtained. This was then washed, dried and observed under the microscope for surface uniformity. Elemental analysis of X-ray film base was done. It was characterized as cellulose acetate with the chemical composition $C_{10}H_{14}O_7$ and density 1.30 g/ml. Small pieces (1 cm $\times$ 1 cm) of X-ray film base (thickness $\sim$ 190 µm) were used for the present experiment.

Transparent plastic sheets of overhead projector (PHOTOPHONE) have also been used for track registration and development. Small pieces (1 cm $\times$ 1 cm) were cut from the triacetate roll of overhead projector transparency and examined under the microscope for surface texture. The surface was found to be fairly smooth with no interfering background. This plastic has been characterized as cellulose triacetate ($C_3H_4O_2$) having density 1.08 g/ml. The averge thickness of the transparency foil was $\sim$ 100 μm.

2.2. *Irradiation*

A 20 ng ^{252}Cf source having an activity of $\sim 6 \times 10^3$ fission fragments was used for irradiation of these detectors. The foils were mounted on a holder in such a way that the collimated ions were allowed to enter at an angle of 30°C with respect to the surface. An aluminium collimator (length $\approx$ 9 mm) was used for irradiation with several holes of diameter 1 mm each. The irradiation was carried out in a vacuum desiccator for 15 mins. Several pieces of X-ray film base as well as the overhead projector transparency were irradiated in this manner. The X-ray film base was also irradiated at 45° with 17.1 MeV/u ^{208} Pb ions at UNILAC, GSI Darmstadt. One sample was pre-exposed to UV radiation for 1 hr prior to irradiation by ^{208}Pb beam.

2.3. *Etching conditions*

The most suitable etching condition for X-ray film base was found to be 2N NaOH at 55°C. For the overhead projector transparency (OPT) the best etching of fission fragment tracks was found to occur in 6N NaOH at 55°C. On etching for 90 minutes, fully etched tracks were obtained in overhead projector transparency irradiated by ^{252}Cf source, while in 75 minutes fully etched tracks were obtained in X-ray film base. For X-ray film base irradiated wifh ^{208} Pb beam at an energy of 17.1 MeV/u tracks were fully etched in 225 minutes. After etching the samples were washed, dried and the track lengths and diameters were measured with a Leitz 'Laborlux D' optical microscope at a magnification of 625X.

2.4. *Measurement of track parameters*

The etched tracks were found to be conical in shape and parallel to each other. Projected track lengths were measured from end to end. The track diameters were also measured as the minor axes of the elliptical track face. About 200 tracks were measured in each foil. The bulk-etch rate (V_G) was determined by the track diameter method. It was found to be 0.0117 μm/min for X-ray film base and 0.0146 μm/min for overhead projector transparency. The true track length was calculated from the projected track length (l) taking into account the surface etching corrections (Δs). The true track length (L) was calculated from the following equation (Dwivedi and Mukherji 1979).

$$L = \frac{l}{\cos\phi} + \frac{V_G t}{\sin\phi} \tag{1}$$

where ϕ is the incident angle.

2.5. *Computation of track length*

A computer code 'RF' (Dwivedi 1988) was used to calculate the track lengths of median light and median heavy fission fragments. The track lengths are first calculated in individual elemental constituents of complex material and then by Bragg's additivity rule the track length in complex media are computed. The values of mass, charge and kinetic energies of median light and median heavy fragments are taken from Schmitt *et al* (1966) and are given in Table 1. Using these data

Table I. Values of the mass, charge and energy of the median light and median heavy fission fragment particles from ^{252}Cf source.

Type of particle	Mass	Charge	Energy
Median light	108.55	42.55	106.2 MeV
Median heavy	143.45	55.45	80.3 MeV

the most probable track lengths of fission fragments in X-ray film base and OPT were calculated from the followiug equation.

$$\langle L \rangle = \frac{L_{ML} + L_{MH}}{2} \tag{2}$$

where L_{ML} and L_{MH} are the track lengths of median light and median heavy fragments respectively. The theoretical track langth for ^{208}Pb ions was calculated from the computer code 'RANGE' (Dwivedi 1988) based on stopping power equations of Mukherji and coworkers (Mukherji and Srivastava 1974, Srivastava and Mukherji 1976, Mukherji and Nayak 1979).

3. Results and discussion

The X-ray film base detector which was pre-irradiated with UV-radiation was found to bend during the etching process. Therefore tracks due to 17.1 MeV/u ^{208}Pb ions could not be measured. On the other hand, the UV-unexposed detector foil revealed narrow and well developed tracks on etching for 225 mins in 2N NaOH at 55°C. Figure 1 shows the track length distribution curve of ^{208}Pb in X-ray film base. The maximum etchable track length was found to be 213 ± 3.0 μm for 17.1 MeV/u ^{208}Pb ions. The corresponding theoretically calculated value from

Table 2. Experimental and theoretical values of the maximum etchable track lengths of ^{252}Cf fission fragments in X-ray film base and overhead projector transparency.

Name of the material	Maximum etchable track length in μm	
	Experimental	Theoretical*
X-ray film base	19.8 ± 2.1	20.3
Overhead projector transparency	23.3 ± 1.9	24.7

* Calculated from computer code RF (Dwivedi 1988).

the computer code RANGE (Dwivedi 1988) was found to be 225 μm which is nearly 6% higher than the experimental value.

Projected lengths of fission fragment tracks were measured in X-ray film base detector. The maximum etchable true track lengths were then obtained from eq (1).

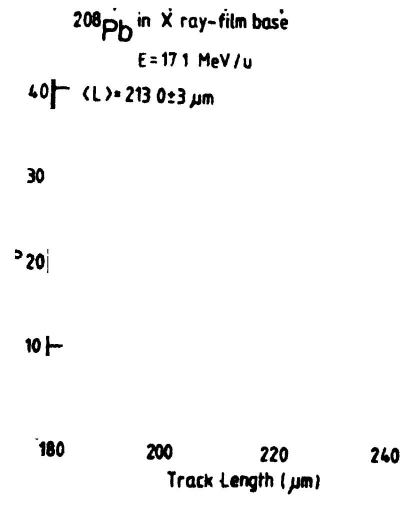

Figure 1. Track length distribution curve for 17.1 MeV/u ^{208}Pb in X-ray film base detector. The most probable track length was found to be 213 ± 3.0 μm.

A track length distribution curve was plotted and is shown in Figure 2. The most probable track length of fission fragments in X-ray film base was found to be 19.8±2.1 μm. The theoretically calculated value from the computer code RF (Dwivedi 1988) was found to be 20.3 μm. In the case of overhead projector transparency, the track length distribution is shown in Figure 3. The maximum etchable track length was found to be 23.3 ± 1.9 μm. The theoretically calculated value was found to be equal to 24.7 μm.

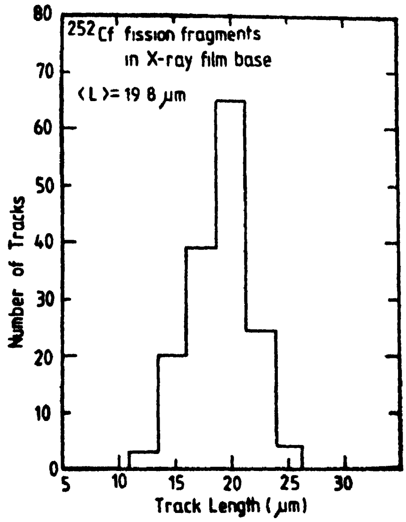

Figure 2. Histogram showing track length distribution of ^{252}Cf fission fragments in X-ray film base detector.

It has been observed that in these two track detectors the theoretical ranges of ^{252}Cf fission fragments are in fairly good agreement with the experimental values of maximum etchable track lengths.

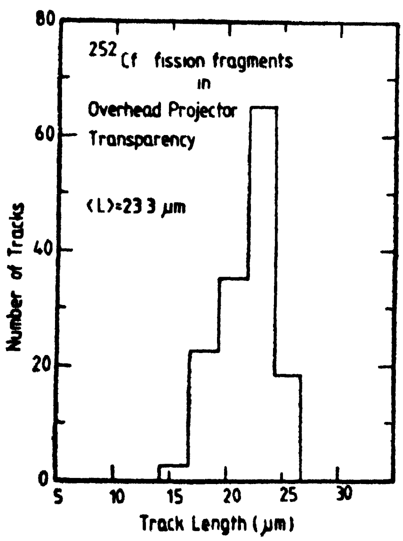

Figure 3. Histogram showing track length distribution of ^{252}Cf fission fragments in overhead projector transparency.

Earlier reported work (Dwivedi and Mukherji 1979) on ^{252}Cf fission fragment tracks in mica, Lexan and cellulose acetate showed a good agreement of experimental values with the theoretically calculated values from the stopping power equations of Mukherji and co-workers (Mukherji and Srivastava 1974, Srivastava and Mukherji 1976 and Mukherji and Nayak 1979). This indicates that the computer code RF (Dwivedi 1988) gives fairly reliable range and track length values of fission fragments in complex materials.

Acknowledgments

We thank the staff of UNILAC, GSI Darmstadt for irradiation of X-ray film base detector with ^{208}Pb ions. We are also grateful to the German Agency for technical cooperation (DGTZ), FRG for an equipment grant.

References

Dwivedi K K and Mukherji S 1979 *Nucl. Instrum. Meth.* **159** 433
Dwivedi K K 1988 *Nucl. Tracks. Radiat. Meas.* **15** 345
Mukherji S and Nayak A K 1979 *Nucl. Instrum. Meth.* **159** 421
Mukherji S and Srivastava B K 1974 *Phys. Rev.* **B9** 3708
Schmitt H W, Neiler J H and Walter F J 1966 *Phys. Rev.* **141** 1146
Srivastava B K and Mukherji S 1976 *Phys. Rev.* **A14** 718